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Tipularia

A BOTANICAL MAGAZINE

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Hugh Nourse *Macranthera flammea,* **Hummingbird Flower**

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Vicky Holifield drew the illustration of *Rhus michauxii* used on the front cover of the Fall 1990 issue of Tipularia and reproduced in this issue with her permission. She is now with the editorial department of Peachtree Publishers.

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Plant Conservation by Propagation

The Cases of *Macranthera* and *Schwalbea*

by Ron Determann, L.Katherine Kirkman and Hugh Nourse

The most cost-effective approach to rare plant conservation is habitat protection. The most common causes of decline in rare species are destruction of habitat from urban development, stream impoundment or clearing of forests for agricultural or forestry use; habitat fragmentation, altering fire corridors or dispersal corridors; habitat degradation from influx of diseases, parasites, predators or competitors that are not native; suppression of wildfires or flooding regimes that maintain certain environments; and the spread of aggressive exotic plants, such as *Ligustrum sinense* (Chinese privet) and *Lonicera japonica* (Japanese honeysuckle) (Patrick *et al.*, 1995). Although management actions are taken to counter these causes on designated lands in order to preserve and protect habitats, many species continue to decline from unknown causes.

Horticultural studies in propagating plants provide a critical bridge between habitat loss with possible extinction and species recovery (Yatskievych and Spellenberg, 1993). An example is *Elliottia racemosa* (Georgia plume). Experiments in propagating from seed or cuttings may enable researchers to learn why *Elliottia* is not reproducing sexually in the wild (Ceska and Affolter, 1997). Plant rescues, reintroduction to the wild, botanical garden research and educational garden displays would be impossible without information gained from such horticultural studies.

The native-plant conservation program of the Fuqua Conservatory at the Atlanta Botanical Garden was started in 1989. The relationship between the endangered species of *Sarracenia* and pitcherplant bog habitats became a focus of their efforts. The development of protocols for propagating endangered plants for conservation purposes has been an on-going objective at the Conservatory. Two plants that have been propagated successfully, after five years of experimentation, are *Macranthera flammea* (hummingbird flower) and *Schwalbea americana* (American chaffseed), both hemiparasitic species in the family Scrophulariaceae.

Schwalbea is listed as both a federally and a state endangered plant. *Macranthera* is not federally or state protected. It is, however, among the plants monitored by the Natural Heritage Program of the Georgia Depart-

ment of Natural Resources because of its rarity. Perhaps it should be listed; it is a protected plant in Florida.

We will discuss the biology, habitats and propagation protocol for *Macranthera* first. Next we will take up the case of *Schwalbea.*

MACRANTHERA FLAMMEA

Macranthera flammea is a large and coarse biennial growing from 15 to 30 dm tall. The stem is rounded but four-angled and is unbranched until the flower cluster. Leaves are opposite, about 8 to 10 cm long, finely dissected and reduced upward. The lower entire leaves are shed when the plant flowers. Flowers are large and showy, borne on stalks along an elongated axis, with the younger flowers near the top. The bright orange corolla is about 2.5 cm long, and from it are exserted four large stamens with very pubescent filaments and a thread-like style. The calyx is about 1.5 cm long, with 5 lobes much longer than the tube. The habitat includes bogs and wet thickets, edges of swamps and occasionally shallow water of cypress-gum ponds or depressions (Godfrey and Wooten, 1981).

The plant seems to require flowing water, as in seepages, rather than standing water. Its range is the coastal plain from south Georgia through the Florida panhandle westward to eastern Louisiana.

The records of the Natural Heritage Section of the Department of Natural Resources (discussions with Tom Patrick) show locations in 7 counties: Bulloch, Crisp, Early, Emanuel, Tattnall, Turner and Worth. The photograph on the cover was taken in Tattnall County near Manassas, Georgia. The main reason for few sites in Georgia may be loss of habitat. The primary causes for this loss appear to be herbicide use in agriculture and forestry, the continuing drainage of wetlands, fire suppression and agricultural eutrophication. Eutrophication occurs when fertilizers used in agriculture drain into wetlands, causing excess plant growth competing with *Macranthera.*

Schwalbea flammea

Photo by Hugh Nourse

Pollination

Macranthera flammea is pollinated by hummingbirds (Pennell, 1935). There is speculation that *Macranthera* has evolved from *Aureolaria*, a bee-pollinated plant. *Macranthera* differs by being orange rather than yellow and by the extension of its elongated filaments and style. These characteristics may be adaptations to pollination by birds. Since hummingbirds prefer red, its color may eventually become red. Nonetheless, botanists in the field at one site in Georgia have commented on the number of butterflies working on the *Macranthera* plant.

Hemiparasitic Character

In 1972 Musselman (1972) documented for the first time the root-parasitic nature of *Macranthera*. *Macranthera* is a hemiparasite, hemiparasites being only partially dependent on a host for food or water because they themselves contain chlorophyll and are photosynthetic. The connecting structures between host and parasite are called haustoria.

Musselman (1972) documented host plants for *Macranthera* at three sites in Alabama and Florida. The characteristic habitat was low, wet, sandy soil with abundant plants of *Eremochloa ophiuroides, Aletris farinosa* (colicroot), *Centella asiatica, Eriocaulon decangulare* (pipewort), *Lachnocaulon tinctoria, Mimulus alatus* (monkey flower) and *Rhynchospora cephalantha* (beak rush) at the edge of thickets of *Alnus serrulata* (alder), *Clethra alnifolia* (sweet pepperbush), *Magnolia virginiana* (sweet bay) and *Myrica cerifera* (wax myrtle). Interestingly, although the roots of *Macranthera* were entangled with herbaceous plants, the only parasitic connections were found with woody plants. Haustoria from *Macranthera* were found on roots of *Nyssa sylvatica* var. *biflora* (black gum), *Myrica* and *Rubus cuneifolius* (blackberry).

Under natural conditions it is extremely difficult to trace the parasitic connection of any root parasite to its host plant. As a result, most research has been conducted by growing the parasite in culture with different hosts. Musselman and Mann (1978) found that *Macranthera* made haustorial connections to 18 different commercial tree species.

Of the 19 species tried, only *Pinus clausa* (sand pine) did not show haustorial connections with *Macranthera*. Besides gum trees, *Macranthera* attached to *Liriodendron tulipifera* (tulip tree), *Carya illinoensis* (pecan), *Quercus alba* (white oak) and *Taxodium distichum* (bald cypress), as well as to *Pinus taeda* (loblolly pine). Nonetheless, the researchers found that *Macranthera* prefers *Nyssa*, because it tends to grow largest when attached to this host.

Developing a Protocol for Propagation

When R. Determann first encountered this beautiful plant while studying *Sarracenia* bogs in the Florida panhandle and adjacent southern Alabama in the early 1980s, he had a hard time identifying the species. Wildflower guides to the area were of no help, and it took a return visit with field botanists to shed some light on the matter. However, he knew one thing: He was determined to

grow this spectacular plant some day. Seed was collected in the late fall, and germination, after the typical four weeks cold stratification, was encouraging. After a year of careful nurturing, a few seedlings formed small rosettes, but none showed any tendency to become flowering plants, and all eventually perished. At that time he didn't understand the hemiparasitic nature of the plant and its specific growing requirements.

Years later, he again encountered the magnificent *Macranthera* and was again determined to try growing it. The location was near Carriere, Mississippi, where a local resident, Mr. Coleman Tarnok, had, over a time span of 35 years, created a fantastic pitcherplant bog with all of the southeastern companion plants: orchids, Venus' fly traps, all species of *Sarracenia, Utricularia* spp., *Pinguicula* spp. and *Macranthera flammea.* Many of the companion plants were probably accidental, and many came with the introduction of the pitcherplants.

Careful observations were made about how the plants grew and responded to fire. Through the use of fire in Mr. Tarnok's bog, the old bay swamp was gradually opened up, and *Macranthera* was found growing with small *Magnolia virginiana, Ilex glabra* sprouts and many sedges and grasses on a deep sphagnum-covered hillside seep. Using these observations and knowledge of its hemi-parasitic nature, Determann initiated several years of trials. The following replicable procedures for growing *Macranthera* in the greenhouse and the laboratory were developed.

In the greenhouse

Ripe seed is collected in the fall and sown out on top of a pot with a 5:1 peat-and-sand mix that is covered with a very thin layer of milled sphagnum moss. Please note that the seeds probably need light to germinate, so do not cover the seed. Place it on top of the sphagnum moss. This mix is thoroughly wetted down, covered with transparent plastic foil, secured with a rubber band and placed in a dish of water in the refrigerator for 4 weeks for cold stratification.

Then the pot is placed, still covered with plastic, under fluorescent lights with a daylight regime of 17 hours or more. Uniform germination takes place in about 2 weeks. After two to three weeks, the potting mix needs to be fertilized with a dilute fertilizer (*e.g.*, a 30-10-10 NPK-ratio fertilizer at 1/4 strength) to keep the seedlings going. The seedlings can now be

Macranthera flammea

Photo by Carol Nourse

gradually uncovered. Once the plants have their own true leaves, they can be separated and put into individual pots, with or without their hosts. Note that the plants are still very fragile, and their very fine roots are entangled and break off easily. If the plants are planted without their host plants, nutrition becomes very difficult, and a very open acid organic mix with high cation-exchange capacity must be used. So far, plants without hosts fail to flower but can be maintained for a long time.

After extensive experimentation with various woody plants, such as *Ilex glabra* and *Magnolia virginiana,* and grasses such as *Sporobolus teretifolius* (dropseed) and *Aristida stricta* (three awn grass), it has been found that the best results are obtained by placing the seedlings onto either *Juncus effusus* or *J. canadensis* (rushes). The rush roots are exposed, and the tiny *Macranthera* roots are placed directly on the rush roots.

Best results are also obtained by using a media mix that is acid, highly organic, holds lots of water and still has a degree of aeration, rather than using commercial soil-less mixes. Our final mix consists of peat and sand 5:1 (1 part), long fiber sphagnum moss (1 part) and a mix of equal parts of fine charcoal, fine fir bark and pumice (1 part total). Once the plants get through the critical stage of establishment onto their hosts (see picture), they respond favorably to some supplemental slow-release fertilizer, such as a 17-6-12 NPK, to get them to mature.

The best time to establish the seedlings is in the beginning of the growing season, March to April. Plants form a rosette by fall and will be flowering the next season, consistent with their biennial habit. Sometimes offsets formed at the base of the mature flowering stalks can live on their own, giving the appearance that the plant is a perennial.

In the laboratory

While the above protocol was established in the greenhouse, R. Gagliardo, the Tropical Plant Curator and manager of the tissue culture facility at the Atlanta Botanical Garden's Fuqua Conservatory, established methodology for growing seedlings *in vitro* using tissue culture media. The advantages of this method are that it will give faster overall results and larger plants, and it makes it easier to establish the plants from the laboratory onto their hosts. For conservation recovery of the species, it is desirable that seedlings grown *in vitro* are harvested from as many seedpods and motherplants as possible to

***Macranthera flammea* roots placed directly on the host roots**

Photo by Ron Determann

maintain maximum possible genetic variance rather than proliferating multiple identical clones.

In brief, the laboratory procedure is as follows: Unripe and unopened (green) seedpods of *Macranthera flammea* are surface-sterilized in a 15% NaOCl solution (equivalent to 30% commercial bleach in water) for 30 minutes. The pods are removed and rinsed three times with sterile water and then dipped in 95% ethanol for 1 minute.

After flaming to remove the excess ethanol, the pods are opened and the seeds are placed on sterile medium. The germination medium consists of 1/3 strength Murashige and Skoog Minimal Organic Salts supplemented with thiamine (0.4 mg/l), inositol (100 mg/l), sucrose (20 g/l) and Phytagel (6 g/l). Germination occurs in 96 hours.

Seedlings grow quickly and after 4 weeks are moved to multiplication medium (same as above with the addition of 1 mg/l Kinetin). Axillary shoot multiplication is evident in 6 weeks and "clumps" of plants are then divided and subcultured to fresh medium. (Do not add NAA [Napthalene Acetic Acid], as the addition of 0.1 mg/l of NAA results in callus formation and shoot deformities. The effects are quite persistent, requiring several transfers to fresh medium in order to "flush out" the NAA.) Rooting is spontaneous on the multiplication medium. Large seedlings can be obtained from the *in vitro* growing within 4 months.

Rooted plants are established in the greenhouse after 8 months in culture. The mix described in the greenhouse procedure above for establishing seedlings onto their hosts is used. After 6 weeks on their own, with no apparent size increase in a high humidity situation, laboratory seedlings are established onto their hosts.

Using this method over the past few years, some plants have flowered, including some plants 24 dm tall. Further experimentation is underway with other possible hosts, such as *Ctenium aromaticum* (toothache grass), *Pinckneya pubens* (fever-tree) and *Myrica heterophylla* (bayberry).

SCHWALBEA AMERICANA

Schwalbea americana, a federally endangered species (USFWS 1992), occurs primarily in fire-maintained longleaf pine habitats of the southeastern United States. Its original range from Florida to New York has been drastically reduced to small isolated populations in only five southeastern states (FL, GA, NC, SC, NJ). Many populations have been extirpated due to habitat destruction from development, agricultural clearing and loss of fire-maintained habitat.

Schwalbea historically occurred in sandy soils of open to partially-open and frequently burned pine flatwoods, dry-moist grass-sedge savannas and edges of wetlands. Many of the extant populations in Georgia and South Carolina are on private lands managed with dormant season burns for quail production. Other surviving populations are found on sites such as military installations and powerline rights-of-way, where fire or mowing has maintained an open habitat (USFWS 1995).

Life history

Schwalbea is a non-host-specific root parasite, as are many genera in the same family. Known hosts (in field and greenhouse studies) are many, including *Liriodendron tulipifera* (tulip tree), *Pinus strobus* (white pine), *Liquidambar styraciflua* (sweet gum), *Nyssa sylvatica* (black gum), *Nyssa aquatica* (swamp tupelo), *Ilex glabra, Gaylussacia dumosa (*dwarf huckleberry), *Hypericum* sp. (St. John's wort), *Aletris farinosa, Panicum tenue* (panic grass), *Pityopsis graminifolia* (silkgrass), *Dyschoriste oblongifolia, Carphephorus odoratissimus* (dog tongue) and *Aristida stricta* (wiregrass) (Musselman and Mann 1977, Kirkman and Musselman, unpublished data).

It is unclear at what points in the life cycle or climatic/nutrient regimes parasitism is critical to *Schwalbea*, but is likely to be at the early establishment phase. Greenhouse-germinated plants can survive for many months without a host or nutrient supplement but will not grow much beyond the young seedling stage. According to studies by Mann and Musselman (1981) and personal observations of K. Kirkman and R. Determann, individuals provided with soil fertilizer or nutrient agar can attain mature growth form without attachment to a host. Given the lack of host-specificity, it is unlikely that the parasitic aspect of the life cycle contributes to its overall rarity, although successful re-introduction of *Schwalbea* into former habitats with greenhouse-germinated seedlings may require use of hosts or nutrient substitutes to obtain large enough seedlings for transplantation.

The common name, chaffseed, comes from the sac-like structure surrounding the seed, which may function in wind dispersal. Seeds are abundantly produced in capsules and germinate readily without cold stratification. To date, there is no evidence to suggest that seeds persist in soil as seed banks for future recruitment. The species is a single– to multi-stemmed perennial which does not propagate by rhizomes. The tubular flowers are creamy-colored to purplish red and appear to be pollinated by common species of worker bumble bees. *Schwalbea* also is capable of producing viable seed in the absence of pollinators (Kirkman 1996).

By applying experimental

Schwalbea americana

Photo by Kay Kirkman

summer and winter fire and summer mowing treatments to populations of *Schwalbea* and following thousands of tagged plants from year to year, we know that fire not only stimulates flower production but influences the timing of flowering. Winter fire stimulates flowering in April-June, whereas June fire stimulates flower production in late July-August. In the absence of fire, individuals remain in vegetative (non-flowering), short-stemmed condition even if they produced flowers the previous year (Kirkman 1996).

Exactly how the plant detects this cue is unknown. An obvious possible explanation is availability of light which is increased by removal of the ground cover through burning. However, other possible factors are nutrient changes following fire or the release of growth stimulants in the smoke. Although populations of flowering *Schwalbea* have been located in mowed powerline rights-of-way, experimental treatments with summer mowing did not produce flowering or survivorship results similar to that of winter or summer fires (Kirkman 1996).

In addition to questions about the fate of seeds in the soil and the physiological mechanisms which promote flowering, we know little about the ability of *Schwalbea* to persist in the absence of fire and still recover after fire is resumed. In fact, we do not know how long these plants can live (*e.g.*, many individuals tagged in 1992 were still alive by the 1996 census). We do not know how far seeds are dispersed or what triggers seed germination in the field. We also have little knowledge about the impacts on the species of other disturbances such as winter mowing, herbicide application, soil discing, pine-straw raking, timber harvesting or fertilizer application.

Conservation opportunities

How can the information we know about the life cycle of this rare plant be used to help in the conservation/protection of this extremely rare species? Key habitat preservation and management efforts are related to the obvious fact that frequent fire is necessary for the long-term maintenance of the habitat and populations of *Schwalbea.* Based on 5 years of study, populations which are frequently burned appear to be stable and can probably persist if catastrophic events (*e.g.*, high mortality due to herbivore, human soil disturbance, *etc.*) do not occur.

We do not have evidence to suggest that the timing of the burn has serious consequences on the population structure, because the dormant and growing season fire produced similar results. This is particularly important because many of the extant populations in Georgia and South Carolina are on private lands managed primarily with dormant season burns for quail production.

Because flowering phenology is closely tied with timing of the burn, a burn will remove vegetative material rather than the flowering plants; thus, disruption of fruit set or seed production is not a concern. Winter burns, however, particularly in the wetter habitats, are probably less effective in removing competing

woody species. A fire frequency of 2-4 years would probably be the most desirable based on estimates of fire return intervals for longleaf pine management. Observations of the habitat in which this species occurs would suggest that the species requires a relatively open canopy. Thus, judicious thinning of the canopy might be beneficial to the population; however, care should be taken to minimize impact to the ground cover.

Developing a Protocol for Propagation

After seeing the propagation experiments on *Macranthera*, K. Kirkman encouraged R. Determann to try to grow *Schwalbea americana*. She provided him with biological data for understanding the requirements of this plant and also showed him the plant in the wild at Ichauway Plantation. Fresh seed was obtained in September, and experimentation was started.

In the greenhouse

The fine seed needs just light and moisture to germinate; no cold stratification is required. It is sown out on Nepenthes mix consisting of 1 part fine charcoal, 2 parts milled sphagnum moss, 1 part peat moss, 2 parts fine fir bark and 2 parts fine fern fiber. The pot is thoroughly wetted down and covered with transparent plastic foil. Germination is visible within a week.

Without a host the seedlings do not grow beyond a small stage, even with addition of dilute fertilizer. Eventually, algae take over and choke them. Transplanting can be attempted, but very few seedlings survive.

Since *Ilex glabra* is a host for *Schwalbea americana* in the wild and also is a readily available landscaping plant, it is used as the host plant. The tiny *Schwalbea* seedlings are established onto rooted cuttings of *Ilex glabra*. The cuttings are lifted up in the pots and their now-exposed roots are placed in contact with the superfine *Schwalbea* roots. The potting medium is 5 parts composted pine bark, 2 parts peat moss, 1 part granite sand and 1 part dime-size pine bark chips.

This procedure in the greenhouse results, however, in few (in our work, only two) mature plants. Experiments with other host plants, *Magnolia virginiana* and *Juncus effusus*, have yielded no reliable conclusions because of their small scale.

***Schwalbea* sampling**

Photo by Kay Kirkman

In the Laboratory

At the same time as the above experiments, winter 1994, seed was also sown in the tissue culture laboratory by R. Gagliardo. He established the following protocol:

Seeds of *Schwalbea americana* are surface-sterilized in 5% NaOCl (10% bleach solution) for 10 minutes. In the laminar flow hood, the seeds are transferred to a sterile paper funnel contained inside a glass funnel. The seeds are then rinsed three times with sterile water before being placed onto the medium. The germination medium consists of 1/3 strength Murashige and Skoog Minimal Organic Salts supplemented with thiamine (0.4 mg/l), inositol (100 mg/l), sucrose (20 g/l) and Phytagel (6 g/l).

Germination occurs in 48 hours and the seedlings grow quickly. After 6 weeks they are moved to multiplication media (same as above with addition of 1 mg/l Kinetin). Axillary shoot multiplication is evident in 6 weeks, and "clumps" of plants can then be divided and subcultured to fresh medium.

At this point stem cuttings from these *Schwalbea* plants can be taken and regrown *in vitro* to increase the number of plants. Rooting is spontaneous on the multiplication medium. The cuttings root within a few weeks and multiplication around the base of each cutting is noted within 6 weeks. After 8 months in culture, large 5 cm plants with lots of roots are established into the above-described seedling mix. However, proliferation from stem cuttings adds months to the process and is undesirable for plant conservation because it results in identical clones, thus reducing genetic variation.

The next step is to establish the very finely rooted plants from the laboratory. Special care needs to be taken to maintain high humidity similar to that *in vitro*. It takes several months before the plants are sufficiently hardened off to be established onto their hosts.

Plants from the laboratory are established onto hosts in the above-described seedling mix. Establishment of plants from *in vitro* onto their hosts in winter or even spring will result in flowering plants the next year.

The above method can be used for the recovery of the species. By taking wild host plant cuttings from the same site, both the host and *Schwalbea* can be planted as a unit.

Conclusion

The knowledge of seed propagation of both rare species, *Macranthera* and *Schwalbea*, provides another tool to help prevent their extinction. Reintroduction of these plants into the wild in former habitats is a way of bridging habitat loss, with potential extinction, and species recovery. With the new interest in native plant gardening, perhaps we will someday even find the spectacular flaming *Macranthera* in the nursery trade propagated from seed.

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Cypripedium Gulch

by Rennie Davant

In May, 1996 I was on a "working" trip with the Georgia Botanical Society to catalog plant materials for the Forest Service near Suches. David Emory asked me if I'd like to walk over a couple of ridges to a place where in the past he'd seen scads of yellow lady's-slippers, so that I could then do a layman's article on the area for Tipularia. I jumped at the chance, of course, and we began tramping along a fairly steep hillside toward a ravine (to be known as Cypripedium Gulch), which runs probably half a mile downhill to a stream.

As we drew near it, we passed scattered flame azaleas still in bloom, carpets of ferns and wild huckleberries, and soon I was struck by a magnificent overstory of tall tulip trees which reached up until they seemed almost to touch the sky. Back on earth David helped me identify dwarf crested iris (not in bloom here), a chestnut oak, broad beech fern, the lavender blooms of wild geranium and a shad bush.

It wasn't long before David pointed toward a rotting tree trunk, and there they began: four lady's- slippers clustered around its base. They were completely yellow and a very good size (*Cypripedium pubescens,* the large yellow lady's-slipper). We began to descend the ravine.

Black cohosh, cinnamon fern and northern maidenhair distracted us. Indian cucumber was in flower, and round violet leaves almost completely carpeted the ground in places. We saw horse balm, rattlesnake plantain, yellow mandarin and the first of what would prove to be over fifty (that we counted) showy orchids in bloom!

And still we found yellow lady's-slippers as we made our way down this glade. At one place we stopped and counted 33 blooming plants within our view!

I asked David about a little "moss" I saw, and he immediately identfied it as *Lycopodium lucidulum* (now *Huperzia lucidula*), a rather rare clubmoss that has no cone. We passed rattlesnake fern–and still more and more of these yellow orchids. Our final tally brought us to well over a hundred! Until now all of the yellow lady's-slippers we'd found were completely yellow, but at the bottom of this luxuriant dell we found two smaller ones with brown sepals (*Cypripedium parviflorum*, the small yellow lady's-slipper).

The showy orchids were in abundance as well, although many blooms

were past their peak. It's hard to make an exact count of these small plants because so many were partially hidden by leaves or undergrowth.

It was interesting that all of this fecundity was on the nearer (western) slope of the ravine, the other side probably being drier. Less moisture, I suppose, results in less of botanical interest.

We were leaving the lady's-slippers as we neared the bottom of the ravine, but we still found lots to draw our attention: Fallen yellow-and-green blooms of the tulip trees, scattered as they were in the brown leaves, caught our eye, as did more and more maidenhair, wild yam, a St. John's wort, a jack-in-the-pulpit and cinquefoil (*Potentilla* sp.). Flame azaleas and mountain laurel now covered the opposite bank, absorbing, I suppose, the moisture coming from the creek below. We began to see hemlocks, gnarled dogwood trunks reaching toward the light, lady and interrupted ferns, may apple and meadow parsnip (with the central flower on a stalk).

Cypripedium parviflorum
Yellow Lady's-slipper

Photo by Carol Nourse

Nearer the stream a few white pines began and, on the ground below them, perfoliate bellwort, Catesby's trillium, foam flower and Solomon's seal. We found one other orchid, not blooming, which David tentatively identified as *Liparis lilifolia* (lily-leaved twayblade). A later trip by him confirmed this when he found the little plant in bloom.

The ravine is obviously a fountain of botanical goodies. We did only one cursory walking of it, and it still hasn't been thoroughly explored. Our trip granted us a plethora of riches; still, who knows what else might be found there by the next wanderer!

Chestnuts in Georgia

By Sandra L. Anagnostakis

For some people the word "chestnut" still evokes memories of crisp fall days, the smell of wood smoke and collecting chestnuts for roasting or stuffing a turkey. It has been a long time since there were big American chestnuts in Georgia, but important chestnut research has been done in the state, from studies of which kinds of trees would be best for orchard plantings for nut production to details of lethal diseases and insect pests important throughout the world. Georgia's chestnut history is still being studied by scientists and naturalists today, and new research relies on opportunities present only in Georgia.

The name "chestnut" refers to seven species of deciduous nut-bearing trees found native and introduced throughout the world. The nuts are actually fruits, with the shells enclosing cotyledons. Trees bear both male and female flowers in late spring but must be cross-pollinated for nut production. Nuts are borne in a spiny involucre or bur which opens to release the nuts in late fall.

Tipularia readers will remember an article by Scott Merkle and Claud Brown in the 1991 issue describing "The American Chestnut: Its past, present, and future in Georgia." They discussed past and ongoing work to restore this native tree, which has been ravaged by diseases and insects due to the carelessness of humans. Before we instituted plant quarantine laws, two devastating diseases of chestnut trees were brought into the U.S., but even the presence of the laws did not protect us from a person who wanted some cuttings of chestnut trees that he saw in Asia and thereby brought us a serious new insect pest.

Root Disease

The first of the diseases infected roots and was reported on European chestnuts in Portugal in 1838. The fungus, *Phytophthora cinnamomi*, causes brownish-black lesions on the roots that exude an inky-blue stain. Soon after this, "ink disease" was found in several other parts of southern Europe. Lesions expand, coalesce and girdle the root, and trees are killed when the root collar is girdled or when most of the roots are killed. Breeding with resistant Asian species has produced new cultivars, and careful sanitation and site selection allow European chestnuts to be grown still.

The fungus was assumed to have entered the United States in the mid-1800s, and it probably accounted for the recession of the chestnut from large areas in the Gulf and Atlantic states and inland to the foothills and mountains of Mississippi, Alabama, Georgia, Tennessee, Maryland, Virginia and the Carolinas. USDA scientist G. F. Gravatt wrote to many

people in 1933 to ask when they remembered chestnut trees beginning to die. William L. Telford answered that he had moved to Commerce, Georgia, in 1872 and found "many big dead bare trees, but no living ones." He also observed that the native chinquapins were not affected. J. N. Cheek of Dunwoody, Georgia, attributed the death of the local chestnut trees to the lack of burning in the forest, since he thought that "the ashes went in the ground and killed the worm that affected the roots of the trees and caused their death ...." O. E. Horton, a lawyer in Atlanta, recalled that the chestnuts abounded up to 1850, but that "by 1865 the great bulk of chestnut trees in the Piedmont Section ... were dead." Gravatt and his colleague Margaret Ryan in Beltsville, Maryland, then collaborated with Bowen S. Crandall in Athens, Georgia, to write the definitive paper on this epidemic, with many photographs of chestnuts in Georgia.

The Chestnut Blight

The second disaster for American and European chestnuts was also a fungus disease. *Cryphonectria parasitica* (formerly *Endothia parasitica*) was first reported in New York City in 1904 and was soon found to be widespread in the northeastern United States. Chestnut blight probably entered the U.S. on imported Japanese chestnuts in the late 1800s. Initial spread was on nursery stock (most major mail-order nurseries sold Japanese chestnuts at the turn of the century), but spores were also carried on the fur, feet and feathers of all the birds, insects and other animals that walked up and down the trees.

Wounds in the bark allow access and initial fungal growth, and the resulting canker expands to kill the cambium and eventually girdles the twig, branch or trunk. The fungus does not kill the root collar, and the dormant buds there sprout and grow until wounded, infected and killed, and the cycle is repeated. The natural range of American chestnut is from northern Georgia to southern Maine and west through Ohio, Kentucky and Tennessee. In the north, sprout-clumps have survived well, but further south, repeated chestnut blight cycles kill the sprout-clumps. American chinquapins are also very susceptible to chestnut blight, and their sprouting system (relying on the old root system, instead of forming new roots as chestnut does) may make them more liable to being totally killed by blight.

Disease-Resistant Hybrids

Orchardists in Georgia responded to these problems by taking advantage of the many Asian chestnut trees being imported by the USDA. The presence of an experimental nursery in Savannah provided easy access to trees resistant to both ink disease and chestnut blight.

Japanese chestnuts (*Castanea crenata*) and Chinese chestnuts (*C. mollissima*) are grown in Asia and the United States for their nuts, and many cultivars have been selected. All of the species can be crossed, and hybrids have been selected primarily as orchard cultivars.

Gall Infestation

Now a new pest is threatening our chestnut trees. In 1963, Oriental Chestnut Gall Wasp (*Dryocosmus kuriphilus*) was first reported to be a problem in Japan and Korea. This insect was brought into Georgia in 1974 from Asia on cuttings that did not go through plant quarantine, and Chinese chestnut trees that were grown in Georgia orchards for their nut crop were soon infested. Since its introduction, this wasp has nearly eliminated the chestnut industry (orchards of Chinese chestnuts) in the state. Georgia scientist Dr. Jerry A. Payne first described the infestation in 1975 and has written pest-alerts and articles for the public, besides studying the insect and trying to find a way to combat it. The insect lays eggs in the vegetative and mixed buds, and, as the larvae develop, 1/3- to 1/2-inch, green or rose-colored galls are formed on the leaves, petioles and even catkins (Figure 1). These galls suppress shoot elongation and reduce fruiting, and trees with severe infestations lose their vigor and often die. Jerry Payne planted American chestnut seedlings from Southington, Connecticut, on the grounds of the USDA Fruit and Tree Nut Station in Byron, Georgia, in 1989. By 1992 these trees were heavily galled by the pest, so we knew that the danger to American trees was serious. On 19 June 1993 we found galls on American chestnut trees growing along the Appalachian Trail in the Chattahoochee National Forest in northern Georgia (Union County).

Along the Appalachian Trail

Spread of the gall wasp occurs as a result of movement of infested twigs or shoots or by flight of the adult wasps. After adult emergence, the gall dries, becomes woodlike

Fig. 1. Gall caused by the Oriental Chestnut Gall Wasp on American chestnut.

Photo by J.A. Payne

and remains attached to the tree for several years. Pruning and destroying infested shoots may slow the spread of the insect. Since the Appalachian Trail extends from northern Georgia to Maine, and since American chestnuts are found along the whole length of the trail, there will be a source of host material for the gall wasp to allow it to move throughout the native range of our tree.

Knowing that this pest is in their area, the nurseries selling chestnuts in Georgia, Tennessee and North Carolina will be alert to the potential problem. We are hoping to find some way of combatting this problem before we must face it in the northeast.

Breeding work in Alabama and Tennessee has concentrated on identifying wasp resistance in Asian chestnut trees and crossing this resistance into American hybrids, but I have taken a different approach. Jerry Payne observed that the Georgia chinquapins frequently found in sandy areas were never infested with gall wasp. Since there was a chance that this represented a completely different kind of resistance, I decided to base my breeding for wasp resistance on hybridization with American chinquapins. Many chinquapin hybrids were made by Richard Jaynes in the 1950s and 60s and are still doing well in the plantings in Connecticut. Crosses of the hybrids yielded seedlings for testing, and these, with representatives of three major types of American chinquapins (Allegheny, Ozark and Florida), were planted at the USDA lab in Byron.

While we wait to see how these cope with gall wasp infestation, Jerry and I decided to look at old plantings

Fig.2 This magnificent Chinese chestnut tree in Sandtown, Georgia, may be the state champion; unfortunately, it is heavily infested with gall wasp.

Photo by S.Anagnostakis

of chestnuts in the state and examine them for resistance.

I have all of the old USDA chestnut records and have found many of the early plantings in Connecticut and New York by using them. According to these records, the USDA sent 14,418 Chinese chestnut trees, 3,491 Japanese trees and 4,748 hybrids, as well as 722 trees of other chestnut species, to residents of Georgia. Surely some of these would still be alive! Large plantings included those at The Martha Berry School near Rome, where 2,261 trees were planted in 1937. Cason J. Callaway planted many trees near Hamilton starting in 1935, and James Hobson of Jasper started planting chestnuts in 1917 and selected an excellent Chinese tree to be propagated as cultivar 'Hobson.'

Sharing Seeds and Information

People interested in chestnuts frequently call me with questions, and several residents of Georgia who have large trees have contacted me. W. A. Slayton's 1926 planting of 105 Chinese chestnuts in Washington, Georgia, was a major source of seedlings for farmers in the eastern part of the state. Many of the original trees, as well as their offspring, are still alive. William Parker has a magnificent Chinese chestnut on his property in Sandtown (figure 2), although we can find no records of its origin. This tree is thought by forester Reggie Lanier to be the Georgia champion. Unfortunately it is now heavily infested with the gall wasp, and only persistent attention will save it.

Jerry and I and his former assistant, Ann Amis, went out in search of more old chestnuts in the spring of 1996. In most cases, the USDA cards gave addresses of the plantings, and sometimes they included directions and maps of the areas. With the cards in hand, we started driving around and knocking on doors. We hoped that by looking at a wide variety of imported trees, we would find differences in gall wasp infestation. Residents were usually surprised that the strangers at their doors were there to look at their chestnut trees, but all were pleased to help (a friend of mine has pointed out that "this is the polite part of the country").

There were 35 Chinese chestnut trees planted in Thomaston, Georgia, in 1939 by Aubrey McEachern. These were from two different importations, one from north of the Great Wall and the other from Chekiang Province in Hangchou. Many of the trees were still alive in 1996, and one type was much more heavily infested with gall wasp than the other. Mr. McEachern's son promises to keep an eye on them for us.

Searching for Survivors

The first sign that we found of resistance in the many locations visited was in Knoxville, Georgia. In 1939, E. S. Wright, who was the postmaster at that time, planted ten hybrids. These were seedlings from Walter Van Fleet's hybrid S8. Bowen Crandall examined the trees in 1942 and reported that three of these trees had survived, and they were still surviving in 1996 when Mr. Randall Fair showed them to us (Figure 3). They

had very few galls, although other chestnut trees in the yard were badly infested. Van Fleet's S8 (its row and tree number in the nursery) was Allegheny chinquapin x Japanese chestnut (*C. pumila* var. *pumila* x *C. crenata*). Van Fleet reported that the chinquapin mother-tree was growing in Virginia and that the male parent was one of "several named varieties of Japanese chestnut including Parry's Giant, Killen, and Hale." The Experiment Station has an S8 hybrid backcrossed with a Japanese chestnut released as our cultivar 'Essate-Jap.' My next plantings in Georgia will include seedlings from this tree crossed with American chestnut to see whether the gall wasp resistance that we saw in Knoxville is carried by our tree.

My most exciting "find" was the Cason J. Callaway Memorial Forest in Pine Mountain. Mr. Callaway received 2,192 trees from the USDA between 1935 and 1942 and planted them at his Blue Springs Farm. Most of these were planted in an orchard setting, and many are still alive. In April of 1997 I was shown the plantings by Jason Peoples, the conservation biologist who cares for the forest, and we found that they include survivors of *Castanea Henryi.* These "Pearl Chestnuts" were from Hsiaofeng and Fengchiao, China, collected in 1931, 1933 and 1935. This species was imported many times into the U.S., but the only survivor of this Chinese chinquapin that I knew of was in our plantation in Connecticut. Our tree suffers greatly from the cold winters and barely survives blight infection. Mr. Callaway's

Fig.3 This hybrid S8 chestnut tree, planted by E. S. Wright in Knoxville, GA, and the adjacent 58 trees were nearly free of gall wasp infestation.

Photo by S.Anagnostakis

trees are large and healthy with little blight mortality, AND they have very little gall wasp infestation! I hope that future cooperation with the owners of these trees will allow me to incorporate this resistance into hybrids in my chestnut breeding program.

Jerry has promised to continue searching for old chestnut plantings to look for gall wasp resistance, and I hope that readers of this article will help as well. Very large, old trees with no galls could provide pollen to speed the production of new chestnut cultivars for Georgia and for chestnut growers all over the world.

Readers can also help by reminding others that Plant Quarantine laws are important. Let us hope that no new pests or pathogens will be brought in to threaten our chestnuts.

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Chestnut Trees

Identification of Chestnut Trees

By Sandra L. Anagnostakis,
Phillip Gordon and Fred V. Hebard

Chestnuts have been cultivated for nuts and wood for thousands of years. The name *Castanea* is believed to come from Kastanea, a city in Pontus, Turkey. European chestnuts (*Castanea sativa*) probably originated in southern Russia in the Caucasus Mountains, between the Black and the Caspian Seas. They were planted throughout the Roman Empire, and they now grow wild in Italy, France, Spain and Greece. Chestnuts are also important in Asia, where there are four native species *(Castanea mollissima, C. Henryi, C. seguinii* and *C. crenata).*

In North America, pollen records from the latest interglacial period show that the American chestnut tree, *Castanea dentata,* was present on Long Island 30,000 to 50,000 years ago. The American chestnut was once found all along the Appala-

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Key To The Species of *Castanea*

Leaves to be examined should be fully expanded, from parts of the tree exposed to full sun and not from within 6 inches of flowers.

Group I Leaves hairless, or with only a few short hairs on the mid-vein on the lower surface.

A. Nuts usually 1 to 3 per bur (but sometimes as many as 7 to 10), leaf margins deeply indented.

1. Twigs smooth, lower surface of fully expanded leaves with few glands, leaves 5 to 10 inches long.
   Castanea dentata = American chestnut

2. Twigs with short simple hairs, lower surface of fully expanded leaves densely covered with glands, leaves 2 to 4 inches long
   Castanea seguinii = Dwarf Chinese chestnut

B. Nuts usually one per bur, leaf margins with bristle-like teeth, leaves shaped like willow leaves and 3 to 6 inches long.
Castanea Henryi = Chinese chinquapin

GroupII Leaves hairy on the lower surface, and nuts usually 1 to 3 per bur.

A. Twigs thick and coarse, brown and downy at first and then becoming smooth; leaves 5 to 10 inches long with long hairs on veins of both the lower and upper surfaces.
Castanea sativa = European chestnut

B. Twigs greenish-brown and downy; leaves coarsely serrate with dense or sparse stellate hairs on the lower surface, usually thick and leathery.
Castanea mollissima = Chinese chestnut

C. Twigs delicate, dark reddish-brown and downy, becoming smooth as they mature; leaves with dense or sparse stellate hairs on the lower surface, leaf margins with bristle-like projections instead of deeply-cut teeth.
Castanea crenata = Japanese chestnut

GroupIII Leaves densely hairy on the lower surface, and nuts always single in the burs.

Castanea pumila
var. *pumila* = Allegheny chinquapin
var. *ozarkensis* = Ozark chinquapin

chian mountain range, from Portland, Maine, to northern Georgia. Within this area it grew in mixed hardwood forests, usually on high sandy land, gravel ridges or mountain slopes that were wholly or nearly free from limestone. In the last 150 years it has been planted outside its range in favorable spots (Michigan, Wisconsin) where it has become a forest tree, protected from chestnut blight disease by geography until only recently. American chinquapins, *Castanea pumila,* share the southern part of the range with American chestnuts from Pennsylvania south.

Chestnuts are deciduous trees with short-petioled, prominently-veined, oblong leaves that have coarse-to-fine-pointed marginal teeth or bristles. Male (staminate) flowers are formed in the axils of successive or alternate leaves in early June, in groups of cylindrical catkins (aments) as long as or longer than the leaves. Female (pistillate) flowers form later and on younger wood. The nuts develop in prickly husks called burs (with one r), which open when the nuts are mature (usually mid-September to mid-October).

There are seven species identified by taxonomists. The key and the following descriptions are intended to separate them.

Description of the Species

Castanea dentata

American chestnut

Before ink disease and chestnut blight disease were brought into the U.S., this was a tree 60 to 80 (occasionally 100) feet tall. Now mature trees are uncommon within the native range, and the species is usually found as a shrubby cluster of sprouts 3 to 15 feet tall or as an understory tree 15 to 60 feet tall. The twigs are chestnut brown, and the buds are smooth and brown and asymmetrically bullet-shaped, usually askew on the twig. Leaves are oblong, pointed at the tip and acute at the base where they join the petioles (*i.e.*, canoe-shaped), with coarsely dentate (toothed) margins. Mature leaves are light green and paper-thin.

The most striking difference between American chestnut trees and the other species is their slender, upright growth, and their thinner, smoother leaves, which are more pendent in position. The nuts are sweeter and are generally smaller than all other chestnuts except chinquapins.

Castanea seguinii

Dwarf Chinese chestnut

This species varies from a shrub to a small tree in China, but it is not very winter-hardy in Connecticut. It seems to have little resistance to chestnut blight disease. Flowers form early in the spring and continue to form through the growing season until killed by the first frost. Hybrids are valuable for use as dwarfing rootstocks and for their ever-flowering characteristic.

Castanea Henryi

Chinese chinquapin

I know of only one mature Henryi chestnut in Connecticut, and this tree (in our plantation) is not reliably winter-hardy nor very resistant to

chestnut blight. Trees in western Georgia have little blight and appear to resist Oriental Gall Wasp. Reports from China suggest that the tree is used for timber in that country.

Castanea sativa
European chestnut

These trees were extensively planted in North America starting in 1773 (Thomas Jefferson). The commercial nuts of France and Italy are cultivars called 'Marrone' that are probably European x Asian hybrids. 'Marrone' cultivars have stellate hairs on the lower surface of the leaves and are male-sterile. They were selected by monks in what is now Turkey in the 1100s. 'Marrone' cultivars are usually apple-like orchard trees grafted on European rootstocks, and their nuts are large.

Trees of the pure species are tall and straight like American chestnut trees. Leaves are usually not acute where they join the petiole and have no stellate hairs. Nuts of the pure species are about the size of American chestnuts.

Both types of trees are very susceptible to chestnut blight and are usually not very winter-hardy. There were many hybrids of *C. sativa* x *C. dentata* planted in the U.S. in the last century, including the popular cultivar 'Paragon.'

Castanea mollissima
Chinese chestnut

Both orchard and timber trees have been extensively planted in North America since about 1915. Nuts are small to large and often quite sweet. Chinese chestnut trees range in resistance to chestnut blight from very susceptible (as susceptible as American chestnut trees) to very resistant. Many cultivars are very cold-tolerant.

Castanea crenata
Japanese chestnut

These trees, extensively planted in North America since 1876, were predominately orchard trees. They are usually very resistant to chestnut blight and ink disease, and some cultivars have been selected for their resistance to Oriental Chestnut Gall Wasp. The nuts are medium to very large and often bitter when fresh.

Castanea pumila
var. *pumila* **Allegheny chinquapin**
var. *ozarkensis* **Ozark chinquapin**

Chinquapins can be small, multi-stemmed shrubs or single-stemmed trees 60 feet tall. The taxonomy of the group is still in flux, and other types described in the older literature include *C. ashei, C. alnifolia* and *C. floridana.* They are all very susceptible to chestnut blight disease, but Allegheny chinquapins have been reported to be resistant to the Oriental Chestnut Gall Wasp.

"Picking up Pawpaws" in Georgia

By Dorothy and Brett Callaway

The genus *Asimina* is the northern most genus (and only temperate representative) of the family Annonaceae. This family is famous for such tropical delicacies as the custard apple *(Annona reticulata)* and cherimoya *(A. cherimola)*, but here in temperate regions we satisfy ourselves with picking up pawpaws, the largest edible fruit native to North America. The pawpaw genus *Asimina* contains eight species and one naturally-occurring hybrid. *Asimina incarna, A. longifolia, A. parviflora, A. pygmaea, A. triloba* and the hybrid *A.* x *nashii* are native to Georgia.

Asimina triloba, the most common and widespread species of the genus, is the one generally thought of when pawpaws are mentioned. It is a small deciduous tree up to 30 feet tall with a pyramidal habit and obovate leaves 10 inches long. The leaves have prominent veins and a characteristic drooping appearance. The maroon flowers are borne in the spring just before the leaves emerge. The flowers are small and inconspicuous, 1 to $1^1/2$ inches across. They are perfect and protogynous (the stigmas in a given flower maturing before the stamens), with petals arranged in two whorls of three. The fruits which follow in late summer are cylindrical many-seeded berries, usually ranging in length from 1 to 4 inches, but some specimens produce fruit as long as 6 inches. The trees readily produce root suckers and therefore form small thickets along stream banks and ravines.

The species is native to most of the eastern half of the United States, from two isolated populations in northern Florida to Ontario and west to Nebraska and Texas. In Georgia, it occurs north of a line from Muscogee County to Burke County. The plants in Georgia and Florida are noted by Kral (1960) to be smaller in stature than those found in the northern portion of the range.

The graceful habit and beautiful foliage (which often turns a nice golden yellow in fall) are reason enough to grow *Asimina triloba* in a home landscape, but in recent years the pawpaw's popularity as an edible commodity has risen. With the surge in "edible landscaping" and home orchards, more and more people are learning about this plant, and pawpaws are appearing in gardens everywhere. The fruits are green with skin turning pale yellow-green to brownish-black when ripe. The flesh of the fruit is yellow or orange (rarely white) when ripe, and the texture is smooth and custard-like. One common name of the species is Indiana banana, and the taste of the fruit has been likened to that of a very ripe banana, or banana mixed with mango–but neither of these really describes the indescribable, but decidedly tropical, taste of the pawpaw.

Over the years more than 50 cultivars of *A. triloba* have been selected and named, but only about a third of them are still in cultivation and available in nurseries. Nearly all of the cultivars were selected for larger and/or better quality fruit, and in some cases for early or late maturity. Some of the more popular cultivars include 'Overleese,' 'Sunflower,' 'Rebecca's Gold' and 'Wilson.' Two newly-selected cultivars are 'Wells' and 'Estil.'

Asimina flowers are pollinated primarily by beetles. This is supported by the morphology of the flowers, which is quite similar to that of the flowers of the genus *Magnolia*, with multiple stigmas arranged spirally on a central axis and surrounded by many flat stamens. The heavy pollen grains act as food for the beetles, and pawpaw flowers have small areas of specialized food tissue on the inner petals which also serve to attract beetles. Species such as *A. obovata* and *A. pygmaea* also have a fruity floral fragrance which serves as an attractant. Although the "raw meat" color and musky smell of *A. triloba* and *A. parviflora* flowers have led some to believe that various flies may also pollinate these species, this is not likely. The flowers do attract flies, but it is doubtful if anything other than beetles actually pollinates the flowers.

Pawpaw seeds are dispersed by animals such as raccoons and opossums, which relish the fruit. Immature fruits contain compounds which make eating them unpleasant (much like persimmons), and animals soon learn this, leading to the dispersal of only mature seeds from ripe fruit. Because the fruit is so attractive to wildlife, pawpaws are often grown simply for that purpose, both in wildlife refuges and in backyards. Pawpaws also attract butterflies; the foliage of *Asimina* is a primary food for larvae of the zebra swallowtail.

According to Ellis (1995), fossil records of *Asimina* have been found in New Jersey dating to about 15 million years ago and in Mississippi from between 45 and 55 million years ago. The first written documentation comes from DeSoto's 1541 exploration of the lower Mississippi valley; his writings also support the

Asimina triloba **Pawpaw – Largest edible fruit native to North America**

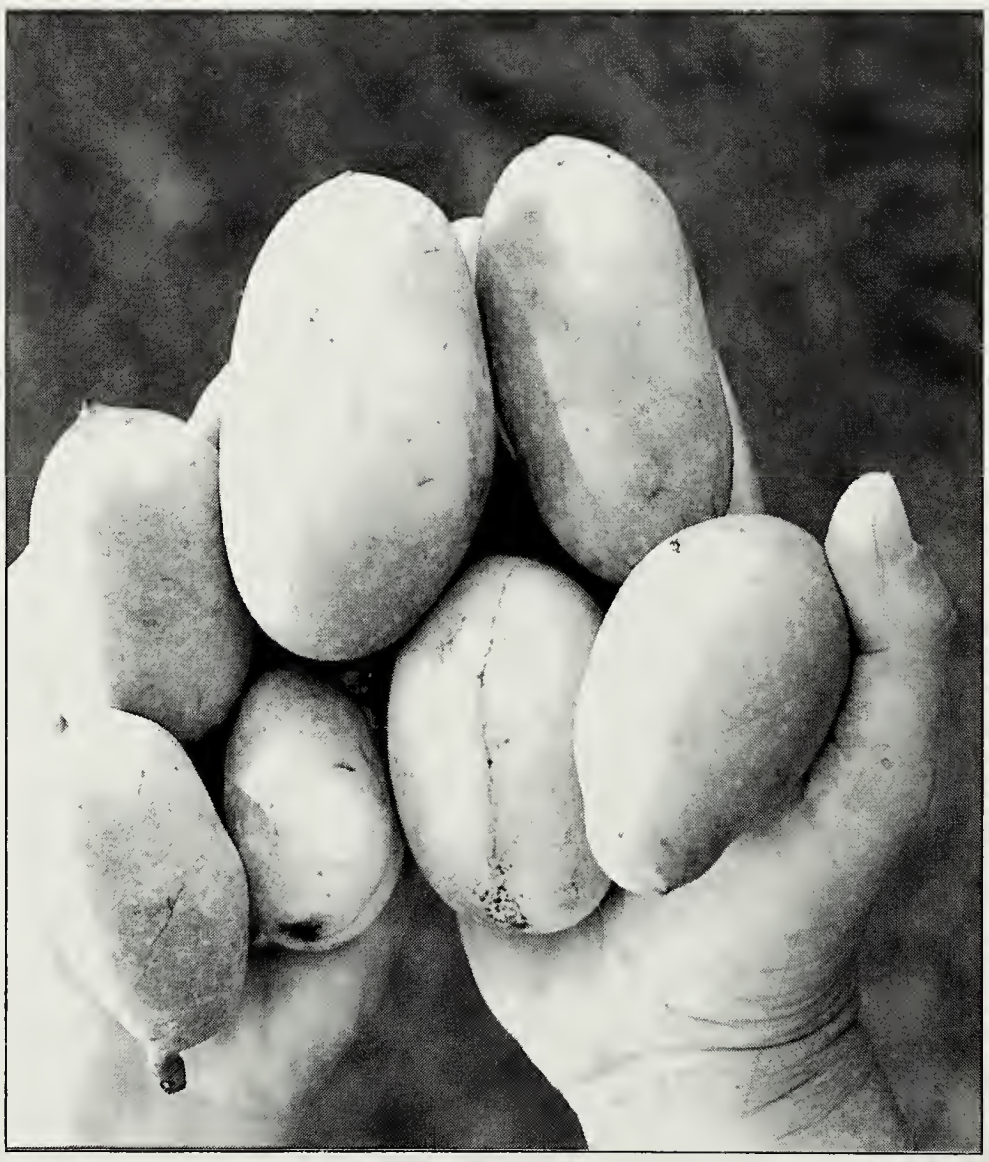

Photo by Jerry A. Payne

belief that certain tribes of Native Americans planted pawpaws for the fruit as well as the fibrous inner bark, which they used for weaving baskets and making a type of cloth.

Plants from the Annona family have traditionally been used by many cultures for medicinal and pesticidal purposes. Recent studies at Purdue University and elsewhere have provided insight into chemicals in pawpaws which may warrant this use. Bark extracts of *A. triloba* have been shown to have insecticidal properties and are effective against Mexican bean beetles, melon and pea aphids, blowfly and mosquito larvae and nematodes. The effectiveness of pawpaw compounds has equaled or exceeded that of pyrethrins and rotenones, two widely used natural pesticides. Part of its effectiveness in relation to pyrethrins comes from the fact that the pawpaw compound is stable in sunlight, whereas pyrethrins are broken down in sunlight.

Studies in the same Purdue laboratory have indicated that a compound extracted from pawpaw bark also has strong anti-cancer properties. The compound asimicin has been effective in killing cancer cells in mice and seems to be a means of bypassing cancer cells' resistance to chemotherapy drugs. Tests are continuing, using asimicin alone and asimicin in conjunction with traditional chemotherapy.

For those interested in growing pawpaws, here are a few tips. Seeds can be collected when the fruits are very soft. The seeds should then be cleaned and kept moist but not soggy. *Asimina* seeds require cold stratification before they will germinate, and this can be accomplished in two ways. They can be planted directly outdoors (in pots or in the ground) in the fall, and the cool winter temperatures will provide the required stratification. If this method is chosen, the seeds must be protected from critters who may want to eat them–a wire screen placed over the pots will suffice. A second method of achieving cold stratification is to put the seeds into a plastic zip-top bag with a *slightly* damp paper towel and place that in the refrigerator at 38-42° Fahrenheit. A fungicide may be added to keep the seeds free of mold. At the end

Asimina triloba **Pawpaw**

Photo by Jerry A. Payne

of 60-90 days, the seeds can be sown as above in the spring, and again they should be protected from animals. Germination should take about 3 months, although fall-planted seeds may take longer. Pawpaws have long tap roots, so be sure to allow for that when choosing a container in which to germinate seeds.

Once the seedlings have emerged and have been grown in the germination container for as long as feasible, they may be transplanted into larger pots or into their permanent location. If choosing larger pots, again keep the tap root in mind. A good container to use is a tall citrus-type treepot (4 inches square at the top and tapering to the base, and 14 inches tall).

Pawpaws prefer a slightly acid soil, pH 5.5-6.5, which is well-drained. Seedlings do best if they receive light shade for the first couple of growing seasons, as young plants can be scorched by ultraviolet light. Once that time has passed, they typically set heavier crops of flowers (and, therefore, fruit) when grown in the sun. Trees usually begin to bear fruit at about 5 to 8 years of age.

Pawpaws prefer a slightly acid soil. Seedlings do best if they receive light shade for the first couple of growing seasons, as young plants can be scorched by ultraviolet light.

Pawpaws are heavy feeders and respond quite well to heavy nitrogen applications. Cutting propagation, layering and root cuttings, of pawpaws has proven to be rather difficult, and superior cultivars are typically grafted rather than cutting-grown. For more horticultural information, see Callaway (1990).

Although *A. triloba* has gotten most of the attention in this article and elsewhere, there are several other pawpaw species native to our state. These are described on page 29, followed by a key to *Asimina* species native to Georgia.

Asimina longifolia
Pawpaw

Photo by Dean Evert

***Asimina incarna* (=*A. incana*, *A. speciosa*)**, the flag pawpaw, is a small shrub of up to 5 feet in height, with obovate leaves, creamy white flowers with a yellowish tinge at the base of the inner petals and edible fruits up to 3 inches long. It is native to sandy ridges and old fields from central Florida to southeastern Georgia, where it is found in Dodge County, south to Lowndes County and east to Wayne and Camden Counties. It flowers from March into April.

***Asimina longifolia* (=*A. angustifolia*)**, the narrow-leaf pawpaw, is a small shrub up to 4 feet tall, with narrow leaves, white flowers with maroon blotches at the base of the inner petals and fruit up to 3 inches long. It is native to flatwoods and sand ridges from northern Florida to southern Georgia and extreme southeastern Alabama. In Georgia, it occurs south of a line from Lee to Wilcox to Toombs Counties and blooms in April and May.

***Asimina parviflora*,** the small-fruited pawpaw, is native from eastern Texas throughout the southeast, south to central Florida and north to southern Virginia. It is found in rich woods throughout the state of Georgia. This species is a large shrub or small tree up to 7 feet tall, with oblong leaves and small maroon flowers appearing in April. *A. parviflora* is distinguished from its closest relative, *A. triloba*, primarily in having smaller flowers, fruits (only about an inch long) and overall size.

***Asimina pygmaea*,** a dwarf shrub less than a foot tall, with obovate or oblanceolate leaves and pinkish maroon flowers, is native to flatwoods, old fields and savannahs from central Florida to extreme southeastern Georgia near Charlton County. It flowers in April, and the fruits which follow are only about 2 inches long.

Asimina* x *nashii, a naturally-occurring hybrid between *A. incarna* and *A. longifolia*, is said to occur where the ranges of the two parent species overlap. It is a shrub with creamy white flowers and leaves intermediate in size between the two parents. In our state, it is known in Wayne, Coffee and Berrien Counties.

Asimina triloba **Pawpaw**

Photo by Brett Callaway

Those interested in growing pawpaws can find seedlings of *A. triloba* at some local nurseries, but cultivars of *A. triloba* and plants of the other species are usually difficult to find except in specialty nurseries or by mail order:

Sweetbay Farm
4260 Enon Road
Coolidge, GA 31738
phone (912) 225-1688

Woodlanders, Inc.
1128 Colleton Ave.
Aiken, SC 29801
phone (803) 648-7522

Key to *Asimina* Species Native to Georgia

(adapted from Clewell, 1985)

Leaves membranaceous, acute or acuminate; flowers reddish

Flowers 1-2 inches across	*A. triloba*
Flowers less than 1 inch across	*A. parviflora*

Leaves coriaceous, linear to oval, never acuminate; flowers various

Flowers arising from previous year's twigs prior to or during leaf emergence; leaves ovate, elliptic or obovate; outer petals white, the inner cream-colored with a yellow corrugated zone	*A. incarna*
Flowers arising in the axils of newly emerged leaves or terminal to them.	
Outer petals up to 1 inch long, pink with maroon streaks, inner petals deep maroon; leaves elliptic-oblong to spatulate	*A. pygmaea*
Outer petals 1-3 inches long, white or pale pink, inner petals white and sometimes pink-streaked or entirely maroon; leaves spatulate to narrowly oblanceolate	*A. longifolia*

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SHOW ME, MICHAUX

By Shan Cammack and Eric Van De Genachte

During the summer of 1996 we had a unique opportunity to search the state for *Rhus michauxii*. Affectionately called Michaux's sumac, or dwarf sumac, this rare shrub was first described by Andre Michaux in 1803. Despite the fact that botanists, biologists and naturalists have scoured this state in search of biological treasures (ever mindful of the elusive dwarf sumac), they, like we, have all come up rather empty-handed. This article details our search and presents the clues we found in hopes that you might help uncover the mystery of the whereabouts of Michaux's sumac in Georgia.

BIOLOGICAL CLUES

Rhus michauxii is a dioecious, rhizomatous shrub, about a half-meter tall with pinnately compound leaves. The oblong or obovate leaflets (between 7 and 13) are toothed. Some-

Illustration by Vicky Holifield

Rhus michauxii

Michaux's sumac, or false poison sumac.

1. Pistillate flower
2. Staminate flower
3. Fruit

times the rachis is narrowly winged near the apex. The plant leafs out during April and May, and in healthy populations it forms dense clumps. Stalks, twigs and leaves are densely pubescent, so hairy, in fact, that botanists in Virginia actually search for the plant in winter, when the pubescent stalks are conspicuous against the stark, leafless background.

The terminal clusters of inflorescences are conical, with the flowers having four to five tiny greenish-yellow petals. Plants bloom between June and August, and plants raised in cultivation, at least, are capable of flowering in their first season. It is common for only half of the stems in a given population to flower, and, typically, males will bloom about a week before females.

Determining the gender of individuals can be difficult since flowers of one functional sex have non-functional parts of the opposite sex. Many populations are composed of only one sex.

The flowers of *R. michauxii* are insect-pollinated and are heavily visited by potential pollinators. As with other species of *Rhus,* Michaux's sumac is probably pollinated by honeybees, bumblebees, butterflies, moths and syrphid flies. The fruit is a drupe, 5 mm in diameter, dark red, fleshy and densely pubescent. Fruits develop between August and October and are often retained throughout the winter. It is believed that fruits and seeds are dispersed by birds. In most populations, seed-set and viability are low, with the primary means of reproduction being asexual, by the spreading of rhizomes.

CLUES ABOUT HABITAT REQUIREMENTS

This federally endangered species has two extant populations in Georgia, 30 in North Carolina and three in Virginia, and it has more than 20 sites of extirpated populations among the states of Florida, Georgia, North Carolina and South Carolina.

Rhus michauxii grows in a variety of habitats in the Piedmont and Sandhills regions. It is typically found growing on sandy soils or in rocky, open woods, but it is sometimes associated with circumneutral soils or soils high in magnesium. Michaux's sumac appears to be dependent on periodic disturbance, which maintains an open habitat. Although plants decline in suboptimal conditions such as heavy shade or mulch and in dense ground-level competition, they may persist as a function of the site's previous, more appropriate conditions.

On military lands, *R. michauxii* often resides in areas which have experienced frequent burning and soil disturbance caused by military procedures, particularly in ordnance testing areas, firing ranges and impact areas. In Virginia, habitat types include hardwood-dominated woodlands (mostly oak/hickory), savannahs and openings in fire-created coppices. Colonies have also been found around old homesites, fencerows, agricultural fields, spoil piles and roadsides. In the Sandhills, *R. michauxii* has been found on loamy sand sites, swales, artillery zones, roadside dumps, parachute drop zones, old fields and rocky forests.

UNDERSTANDING THE GENETICS

Sifting through the literature (both published and unpublished), we found a few studies that specifically investigated the genetics of *Rhus michauxii*. This research was conducted at The University of Georgia in Dr. James Hamrick's lab. Sherman-Broyles *et al.* (1992) compared the levels of genetic diversity between populations of *R. michauxii* and its widespread congeners, *R. glabra* (smooth sumac) and *R. copallina* (winged sumac). They found that *R. michauxii* has much less genetic diversity at the population and species levels than either of the two more widespread species. They also found that Michaux's sumac is, genetically speaking, very similar to *R. glabra,* which may account for the presence of hybrids between the two species. Hybrids appear to be more commonly found in Virginia.

These researchers concluded that low levels of diversity in *R. michauxii* may be due to a combination of factors based on its evolutionary history and its current pattern of distribution. According to their findings, focusing recovery efforts on the most genetically diverse populations may be the best long-term conservation strategy for the species.

Other research in the Hamrick lab examined *R. michauxii* populations in Georgia and Virginia. Although the results have not yet been officially published, their overall findings about Virginia's populations generally concur with those found by Sherman-Broyles (1992). Results from the Anthony Shoals (Elbert County, Georgia) population suggest that its five stems consist of only two genotypes (*i.e.*, two genetic individuals).

WHY IT'S DISAPPEARING

Populations of *R. michauxii* are subjected to various anthropogenic, ecological and genetic threats. Anthropogenic threats include habitat loss or degradation due to agriculture, silviculture and development pressures. Although *R. michauxii* seems to favor disturbed areas (artificial or natural), intensive disturbance activities often destroy populations. Plants growing in edge habitats may be subjected to highway or public-utility-corridor expansion or maintenance (including herbicide treatment and mowing).

Ecologically, *R. michauxii* is a poor competitor and can be shaded out, particularly in areas with fire-suppression. Frequently, once it has been shaded-out, Michaux's sumac does not return, even with subsequent reductions in direct competition. *Rhus michauxii* also seems to be susceptible to root-rot, fungal and scale infection and stem-boring insects, as well as to a powdery mildew. Geographic isolation of small, single-sex populations and hybridization with *R. glabra* compromise the genetic integrity of the species.

RECOVERY EFFORTS

Formal field searches have been conducted in each of the five states where *R. michauxii* has been reported. Most of the known populations are being monitored in Georgia, North Carolina and Virginia. A number of demographic and genetic studies have been conducted, and research

continues to gather crucial information (see the reference section).

Several institutions are cultivating pure stocks of *R. michauxii* from Georgia populations, including (but not limited to) Atlanta Botanical Garden, South DeKalb College Botanical Garden, Woodlanders and the North Carolina Zoo. Crosses of different populations are also being cultivated. This material will be important in recovery efforts by 1) introducing the species to suitable habitat, 2) possibly augmenting existing populations (often to mitigate genetic risks which are associated with small populations) and 3) reintroducing *R. michauxii* to historic locations from which it has been extirpated.

UNLOCKING THE MYSTERIES OF THE PAST:

Historic Populations In Georgia

Historically, *R. michauxii* has been found in Cobb, Columbia, Elbert, Muscogee and Newton Counties, with the first collection from Georgia made by Samuel Boykin in 1845. Ken Wurdack and Bob McCartney (personal communication) confirmed Boykin's specimen in 1989 (it is housed at the Gray Herbarium at Harvard University). Boykin described the collection site as "a few miles south of Columbus," but where exactly was Columbus in 1845, and isn't it possible that a location a few miles south of the town last century is actually well within the modern city limits? Many suspect that the site lies within the Fort Benning Military Base, and several groups are currently conducting faunal and floral inventories on the base.

For our investigation, it was necessary to narrow our search, because Fort Benning contains over 500,000 acres and spans two counties. Some areas were certainly out of the question due to active military operations. Following the advice of North Carolina botanists (who first advised us to touch nothing on the ground which looked suspicious!), we targeted "loamy swales." These areas are slightly loamy and well-drained and have a stronger oak component than surrounding longleaf pine/scrub oak/wiregrass woodlands. We spent several days in the field with our trusty guide, Lee Andrews (USFWS), dodging rattlesnakes and artillery zones, but to no avail. We found a new location for a rare morning-glory, *Stylisma pickeringii*, but, alas, no Michaux's sumac.

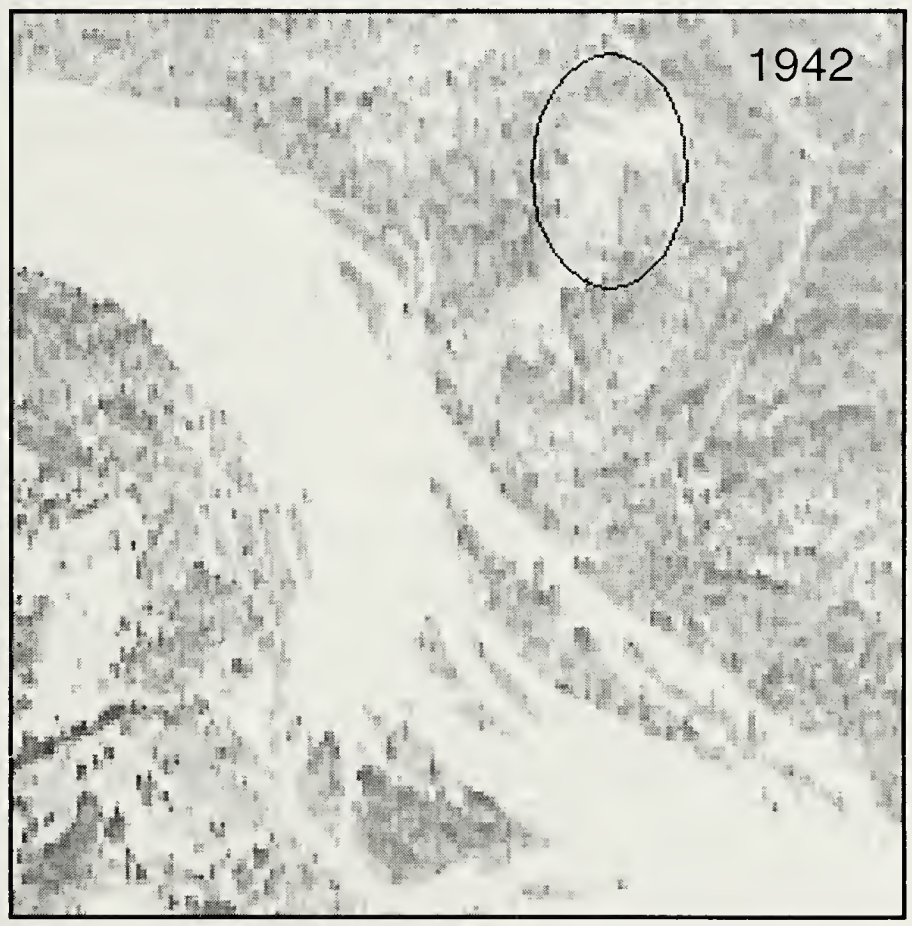
The Cobb County record was also uncovered by Ken Wurdack. The specimen was collected by Charles Boynton in May of 1900. Field notes describe the location as the "edge of a field near Roswell in Cobb County" (which included Roswell at that time). We did not attempt to locate this field site but did search the Pumpkinvine Creek area in nearaby Paulding County.

A collection by Steve Bowling in the 1970s on the Burkes/Dixie Mountain Complex accounts for the Columbia County sighting. Now here was a hopeful venture: a relatively recent sighting AND a collector actually alive and eager to help. As we tried to follow the steps Steve had walked two decades ago, we had a strong sense of the changes that this part of the world has seen. Aerial

photographs over the years chronicle the methodical timbering, as clearcut patches moved across the landscape, ever-widening, and engulfing the natural fabric of the land. Several field visits were made to this expansive complex, on which we did find a considerable amount of potential habitat for *R. michauxii.* Additionally, although no endangered sumac was found, the mountain was full of botanical treats, such as a proliferation of *Elliottia racemosa* and a bountiful blanket of *Marshallia ramosa* in full flower.

The natural population occurring at Anthony Shoals in Elbert County is still extant, although this population has been declining since its discovery in 1950 by Wilbur Duncan. Currently, there are five stems located in two small clumps.

The area is part of the Broad River Management Area, and management efforts have been ocused on the Michaux's sumac. There have been prescribed burns during the dormant season, extensive canopy removal and light harrowing in the vicinity to stimulate growth of dormant rhizomes (if any exist). The new management plan that we developed for the site is conservative in its prescriptions and calls for a continuation of these activities. The plan also includes interesting aerial photos dating back to 1942, which document the slow closure of the canopy and underscore the necessity of continuing these management practices. Cultivated material from this site is currently being grown at the Atlanta Botanical Garden. The single male stem from Anthony Shoals produced pollen this year, allowing pollination of the female Newton County material for the first



Aerial photographs chronicle the canopy closure at the Anthony Shoals site.

time at the Garden.

Finally, there is the transplant site in Newton County (see Fall 1990 issue of Tipularia). Descendants from the original stock collected from this area in the 1950s by Wilbur Duncan were reintroduced in 1990. The location is protected by the City of Covington and is under the management of The Nature Conservancy with the help of the Covington Garden Club.

A SEARCH ACROSS THE PIEDMONT: Mafic and Ultramafic Sites

Sites underlain by mafic or ultramafic rocks are often open, with stunted trees and unique plant assemblages (perhaps due to the high magnesium), and are frequently subjected to wildfires. Thus we targeted ultramafic outcrops for our *Rhus* reconnaissance.

Ultramafic rocks are magnesium- and iron-rich igneous rocks, composed largely (>70%) of dark-colored ferromagnesian or mafic minerals, including olivine, pyroxenes, hornblendes, biotite, phlogopite, serpentine and opaque minerals. Most ultramafic rocks are considered to be ultrabasic, containing less than 45 percent silicon dioxide. Because there are many different rock types in the ultramafic clan which occur in a variety of geologic settings, it is suspected that there are a number of different processes involved in the origin and emplacement of these rocks and that ultramafic rocks are of several different ages. Regional metamorphism produces many intermediate products.

Mafic and ultramafic rocks are common throughout the Piedmont province in Georgia. A number of publications were utilized to identify the ultramafic sites. The *Geology of Selected Mafic and Ultramafic Rocks of Georgia* by Vincent, *et al.* (1990) proved the most useful, providing detailed descriptions and maps. Eleven mafic and ultramafic sites were chosen for this project in the following counties: Cherokee, Clayton, Columbia, Crawford, Elbert, Franklin, Greene, Madison, Monroe, Oglethorpe and Paulding.

The most common community types found on these sites were oak/hickory assemblages and, unfortunately, pine plantations. While several of these sites were fairly open, there was a high degree of variability in community composition, moisture, degree of openness and ecological integrity. In fact, a couple of these sites warrant protection, while others have been completely destroyed by silviculture or development. Interesting plants were found, most notably a new population of *Quercus oglethorpensis* on a curious knob along the Broad River.

[**Editor's Note:** The Georgia Botanical Society began a survey of mafic sites in 1997.]

THE SEARCH MOVES ON: Minor-Monadnocks and other Knobs

Steep, isolated knobs may offer good habitat for our Michaux's sumac. We investigated several knobs which may be classified as the Piedmont Monadnock Forest, a natural community described by Shafale and Weakley (1990). In North Carolina, these sites are monadnocks and high ridges, generally on highly

weather-resistant rocks such as quartzite, rhyolite and pyrophyllite. Soils are rocky, nutrient-poor, well-drained and generally acidic. Piedmont Monadnock Forests generally exhibit low plant diversity, with the canopy strongly dominated by *Quercus prinus.*

Other species include *Q. alba, Q. coccinea, Q. stellata, Q. marilandica, Q. falcata, Carya glabra, C. alba, Pinus virginiana* and *P. echinata.* The understory is typically dominated by *Oxydendrum arboreum* and *Acer rubrum.*

There is a patchy shrub layer consisting of *Vaccinium* spp., *Gaylussacia baccata, Kalmia latifolia* and *Rhus radicans.* The herb layer is sparse, with little diversity; characteristic species include: *Chimaphila maculata, Desmodium nudiflorum, Danthonia spicata, Schizachyrium scoparium, Tephrosia virginiana, Hieracium venosum, Coreopsis verticillata* and *Pteridium aquilinum.*

It is suspected that the exposed position of monadnocks makes them susceptible to disturbances such as high winds and fire (by lightning strike) and that they may have burned more frequently than other Piedmont communities. With fire-tolerant species and sparse vegetation, the community composition and structure are probably not adversely affected by fire. While this community type is uncommon throughout the Piedmont, a number of these monadnocks remain relatively undisturbed.

We visited several Piedmont knobs in Georgia, some of which appeared to be minor-monadnocks. For a number of these knobs, county soil surveys described similar soils (Louisburg Stony Loamy Coarse Sand) and rocky outcrops on the apex. Curiously, these geologic features lie in a southwest-to-northeast orientation in Newton and Walton Counties.

As with the ultramafic sites, these sites varied greatly with respect to degree of openness, community composition and ecological integrity. Some of the larger knobs have had communication towers constructed on their apex. In the interest of protecting the tower, the surrounding land has been fenced off and certain land uses have been avoided. This might increase the chances of a population of *R. michauxii* surviving. On the other hand, it is suspected that natural wildfires would be suppressed here, which would decrease the chances of the sumac's survival by allowing succession and canopy closure. Other potential habitat for *R. michauxii* is found in the cuts for guy-line wires which anchor the towers. These cuts offer a great deal of edge habitat and regular disturbance (clearing and mowing). This kind of disturbance has facilitated the growth of *R. michauxii* in other states. While we were unsuccessful in finding Michaux's sumac, these areas should be kept in mind as potential habitat.

Potential habitat for *R. michauxii* is found in the cuts for guy-line wires which anchor the towers.

CONCLUSION

We shall keep searching (informally) and hope that you will use these clues to do the same. Rest assured that Georgia's two extant populations are in good hands and will be managed carefully. Please call the Georgia Natural Heritage Program (770-918-6411 or 706-557-3032) if you come across *Rhus michauxii.* Your vigilance in this search will certainly help to secure the future of this unique sumac. Finding more natural populations will give the species a better chance of enduring the passage of time by occupying a wider geographic range and by providing more genetic diversity to this endangered species as a whole.

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Bookshelf

Flora of North America North of Mexico

Volume 3 Magnoliophyta: Magnoliidae and Hamamelidae • Edited by Flora of North America Editorial Committee • Oxford University Press, New York, 1997

For the 1994 issue of Tipularia I reviewed Volumes 1 and 2 of this major work, and I now have the next installment. First off, many unfamiliar with suprageneric names will wonder what plants are included in the **Magnoliidae** and **Hamamelidae.** Magnolias are a sure bet, but along with them are: true laurels and sweetshrub; lizard's tails and peppermias; birthworts such as wild ginger and Dutchman's pipe; star anise, like *Illicium floridanum*; water lilies; buttercups and all their relatives; poppies; sycamores and sweetgums; elms, hemp, mulberries and nettles; walnuts and hickories; wax myrtles; oaks; and she-oaks such as beefwood. This volume covers a number of families important in our area, especially in the deciduous forest.

741 species in 128 genera are treated. The largest family treatment by far is that of the **Ranunculaceae** (buttercups) with 285 species on 187 of the book's 590 pages (that means complicated keys!). Next comes the **Fagaceae** (oaks) with 97 species on 71 pages. Four families are monotypic within the area: **Canellaceae** (canella is only known from tropical Florida), **Schisandraceae** (baystar vine is a Georgia native), **Lardizabalaceae** (akebia or chocolate-vine is an invasive alien) and **Leitneriaceae** (Florida corkwood just does make it into the Georgia flora). Other interesting statistics: 17 genera (13%) and 436 species (59%) are endemic to North America, 21 genera and 92 species are introduced and 99 species and infraspecies are of "conservation concern."

Volume 3 continues with the principle of doing no innovation. But a quick glance through shows some changes in familiar names that are bound to raise many eyebrows. For example, hepaticas are considered here to be anemones!

"The taxonomy of *Anemone* continues to be problematic. *Anemone occidentalis* and *A. patens* var. *multifida* (the first two taxa in this treatment) are frequently placed in the genus *Pulsatilla* Miller on the basis of the long plumose achene beaks, and *A. acutiloba* and *A. americana* (the last two taxa in this treatment) in the genus *Hepatica* Miller, primarily on the basis of the involucre immediately subtending the flower and the lobed, persistent leaves. Recent phylogenetic analyses of

Anemone in the broad sense, however, indicate that both *Pulsatilla* and *Hepatica* should be subsumed within *Anemone*. While traditional morphologic characters are useful in distinguishing between *Pulsatilla* and *Hepatica* species, respectively, many other morphologic and molecular attributes are shared with *Anemone*, strongly suggesting that these genera should be united." (pp. 139-140)

You'll note that they do not lump our hepaticas into a single species, *Hepatica nobilis*, or, now, *Anemone hepatica*, as many recent manuals do.

"In North America, *Anemone acutiloba* and *A. americana* are sufficiently well differentiated to enable the distinction of the two species. Some intermediates do occur but it is uncertain as to whether these are true intermediates or hybrids. The fact that the two species are highly sympatric and still maintain their differences implies that they should be recognized as distinctive species." (p. 157)

Some recent works (Kartesz, 1994) have returned to *Carya alba* as the name for mockernut hickory. *Flora of North America* sticks with the more familiar *C. tomentosa*.

"Both the mockernut hickory and the shagbark hickory were formerly known as *Carya alba* (Linnaeus) K. Koch [or *Hicoria alba* (Linnaeus) Britton], based on *Juglans alba* of Linnaeus. A.J. Rehder (1945) pointed out that the original circumscription included two taxa, and *C. alba* (*J. alba*) should therefore be rejected as ambiguous in favor of *C. tomentosa* and *C. ovata*, respectively." (p. 423)

Richard Ware objects to the fact that southern shagbark hickory is here considered, without comment, to be a variety, *Carya ovata* var. *australis*, instead of either *C. australis* or *C. carolinae-septentrionalis*. He also doesn't like *C. ovalis* being subsumed into *C. glabra*:

"*Carya glabra* is a highly polymorphic species. Tight-barked trees bearing large pear-shaped fruits are common along the Gulf Coast (*C. glabra* var. *megacarpa*, *C. magnifloridana*, and *C. leiodermis*). Trees with exfoliating bark, reddish petioles, and small, compressed, ellipsoid fruits that dehisce to the base (e.g., *C. ovalis*) are more common at higher latitudes. *Carya glabra* intergrades with *C. floridana*, *C. pallida*, and *C. texana*, and it is reported to hybridize with the diploid *C. cordiformis* (*C. x demareei* Palmer). The extreme northern *ovalis* form of the species also appears to hybridize with the typical *glabra* in areas of sympatry." (p.425)

I like the way the authors explain their reasons for taxonomic decisions, showing the incredible amount of detail a multivolume work can handle. Each species (and many

infraspecies) account includes complete author citation with publication, major synonyms, full descriptions and a range map. There are 100 illustrations covering about a third of the species. The 1¼- by 1¼-inch base map includes all of North America, so the distribution maps are of limited value. New to Volume 3 are five boxed abbreviations that one has to dig through the introduction to find the meaning of: F=figure (illustrated); C=of conservation concern; E=endemic; W1=weed, *sensu* D.T. Patterson; W2=weed, *sensu* R.H Callahan.

I spent five hours with the book the day it arrived, and I can't wait for the next volume! It can be purchased directly from Oxford University Press by calling 800-451-7556.

Reviewed by L. Scott Ranger

Reference

Kartesz, J.T., 1994, A synonymized checklist of the vascular flora of the United States, Canada, and Greenland, 2nd ed., Timber Press.

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Byliners continued

or three genes for chestnut blight resistance from the Chinese chestnut into a predominantly American genotype.

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Hugh Nourse, Ph.D., is Professor Emeritus of Real Estate at the University of Georgia. Currently he is a volunteer photographer for the State Botanical Garden of Georgia and is field trip chair for the Georgia Botanical Society.

L. Scott Ranger is the editor of the Bot Soc News and frequently does book reviews for Tipularia. He is a past president of the Georgia Botanical Society and recently completed a draft of his *Checklist of the Vascular Flora of Kennesaw Mountain.*

Eric Van De Genachte, a conservation ecologist, formerly worked on pitcher-plant bogs in south Georgia, protecting rare species of *Balduina, Drosera, Myrica, Rhynchospora, Sarracenia, Stokesia* and others. His previous research included genetic studies on two species of *Isoetes.* He is an ecologist for the State of Georgia working on the Flint River Corridor Restoration Project.

Cypripedium calceolus,
Yellow Lady's-slipper,
photo by Hugh Nourse
Story on page 13

Macranthera flammea
Hummingbird Flower
photo by Hugh Nourse
Story on page 2

Asimina longifolia Pawpaw
photo by Hugh Nourse
Story on page 25

Asimina triloba Pawpaw
photo by Jerry A. Payne
Story on page 25